Q12.

A sample of $^{13}_{7}N$ ($t_{\frac{1}{2}} = 10$ mins) contains 6.90×10^{16} atoms of N-13.

a) Calculate its decay constant.

$$\lambda = \frac{0.693}{10 \times 60} = 1.155 \times 10^{-3}\ s^{-1}$$

b) state its initial activity.

$$A_0 = \lambda N$$

$$A_0 = (1.155 \times 10^{-3}) \times (6.90 \times 10^{16})$$

$$= 7.~~96~~ 97 \times 10^{13} \quad (8 \times 10^{13}\ Bq).$$

c) state activity after 1 hour.

(1)

~~$A = A_0 e^{-\lambda t}$~~

~~$= (8.0 \times 10^{13})$~~

$$n = \frac{\text{time taken}}{\text{half life}}$$

$$n = \frac{60 \text{ mins}}{10 \text{ mins}}$$

$$n = 6.$$

$$A = A_0 \left(\frac{1}{2}\right)^n$$

$$= 8 \times 10^{13} \left(\frac{1}{2}\right)^6$$

$$A = 1.25 \times 10^{12}\ Bq.$$

ii) 6 hours.

$$n = \frac{\text{time taken}}{\text{half life}} = \frac{6 \times 60}{10} = \frac{360}{10} = 36$$

$$A = A_0 \left(\frac{1}{2}\right)^n$$

$$A = 8 \times 10^{13} \left(\frac{1}{2}\right)^{36}$$

$$A = 1164.15 \text{ Bq}$$

state after how long will its activity be 1 Bq.

iii)

$A_0 = 8 \times 10^{13}$ Bq

$A = 1$ Bq

$t_{\frac{1}{2}} = 10$ mins

$$A = A_0 \left(\frac{1}{2}\right)^n$$

$$\frac{A}{A_0} = \frac{1}{2}^n$$

$$\log \frac{A}{A_0} = n \log \frac{1}{2}$$

$$\frac{\log 1.25 \times 10^{-14}}{\log \frac{1}{2}} = n = \frac{-13.903}{-0.301}$$

$$n = 46.189$$

$$\text{time taken} = n \times t_{\frac{1}{2}}$$

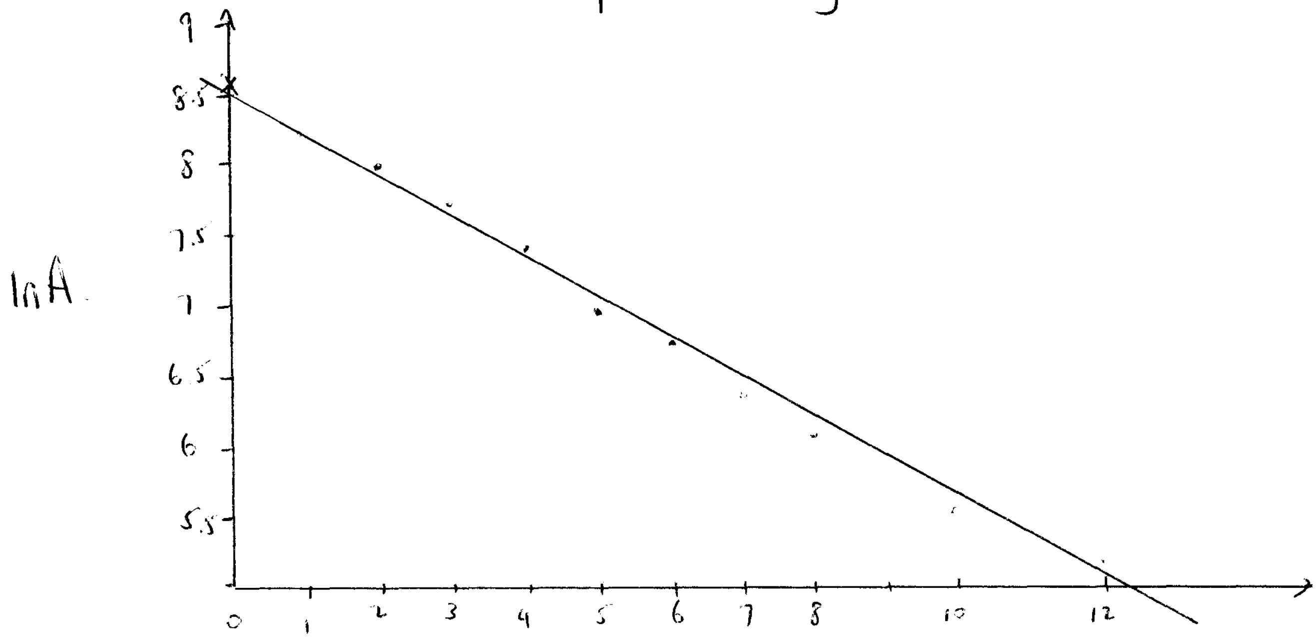
$$= 46.189 \times 10 \text{ mins} = 461.89 \text{ mins}$$

or 7.698 hrs.

Q13 P-32 emits $^{0}_{+1}e$ (positrons)

t (mins)	0	1	2	3	4	5	6	7	8	10	12
A (Bq)	5000	3840	2915	2220	1723	1293	977	745	617	361	209
ln A	8.52	8.25	7.98	7.71	7.45	7.16	6.88	6.61	6.42	5.89	5.34

positron emitting P-32.



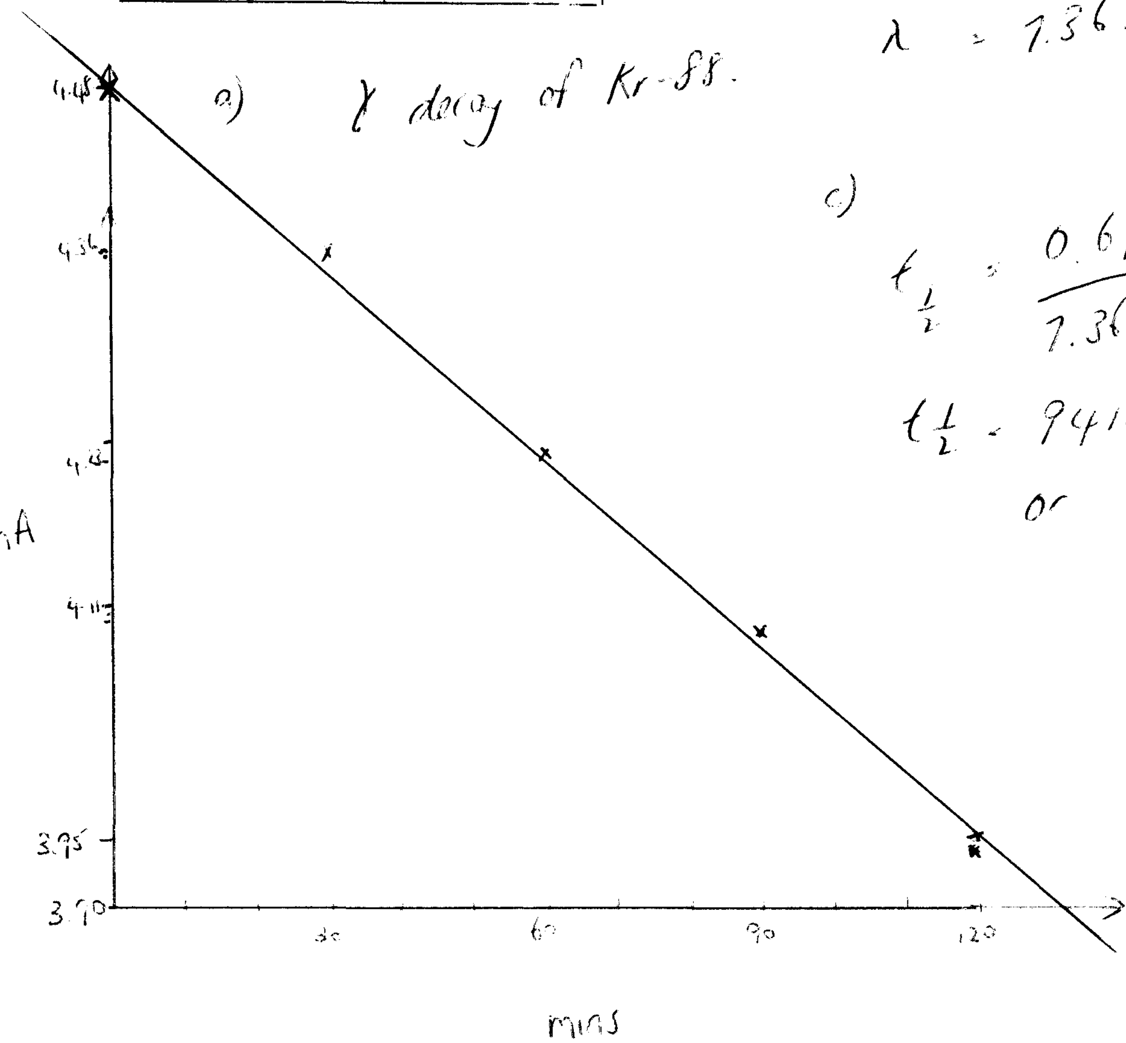
$$-\lambda = \frac{\ln A - \ln A_0}{t} = \frac{5.34 - 8.52}{12} = \frac{-3.18}{12} = -0.265$$

$$t_{\frac{1}{2}} = \frac{0.693}{\lambda} = \frac{0.693}{0.265} = 2.615 \text{ mins.}$$

Q14.

t	A	ln A
0	88	4.48
30	78	4.36
60	69	4.23
90	61	4.11
120	52	3.95

a) γ decay of Kr-88.



b) Determine λ

$$-\text{slope} = \frac{\ln A - \ln A_0}{t}$$

$$= \frac{3.95 - 4.48}{120}$$

$$= \frac{-0.53}{120 \times 60}$$

$$-\text{slope} = -7.36 \times 10^{-5}\ s^{-1}$$

$$\lambda = 7.36 \times 10^{-5}\ s^{-1}$$

c)

$$t_{\frac{1}{2}} = \frac{0.693}{7.36 \times 10^{-5}}$$

$$t_{\frac{1}{2}} = 9415.76\ s$$

or 156.93 mins.

Q15.

C-14 - How old is the wood?

$N_0 = 100\%$

$N = 25\%$

$t_{\frac{1}{2}} = 5730$ years

$$N = N_0 \left(\frac{1}{2}\right)^n$$

$$\frac{25}{100} = \frac{1}{2}^n$$

$$\log 0.25 = n \log \frac{1}{2}$$

$$n = \frac{\log 0.25}{\log 0.5}$$

$$n = 2.$$

total time $= n \times t_{\frac{1}{2}}$

$= 2 \times 5730 = 11460$ years

Q16 $N = N_0 \left(\frac{1}{2}\right)^n$

a) C-14 at 92%

$N_0 = 100\%$

$N = 92$

$n = ?$

$t_{\frac{1}{2}} = 5730$ years

$N = N_0 \left(\frac{1}{2}\right)^n$

$\frac{92}{100} = \frac{1}{2}^n$

$\log 0.92 = n \log \frac{1}{2}$

$n = \frac{\log 0.92}{\log 0.5}$

$n = 0.12$

total time $= n \times t_{\frac{1}{2}}$

$= 689.29$ years

b) $2008 - 689.29 = 1318.71$ A.D.

this is controversial as the shroud is noted as being 32 A.D. (bit of history for you)

Q16.

c) $t_{\frac{1}{2}} = 5730$ years

$$n = \frac{\text{total time}}{t_{\frac{1}{2}}} = \frac{2008-32}{5730} = \frac{1976}{5730} = 0.34485$$

$$N = N_0 \left(\frac{1}{2}\right)^n$$

$$= 100 \left(\frac{1}{2}\right)^{0.34485}$$

$$= 78.74\ \%$$

Q17. Calculate the energy released in J / fission.

a) $^{235}U + {}^{1}_{0}n \rightarrow {}^{90}Sr + {}^{135}Xe + 11\,{}^{1}n + \text{energy}$

m_r:

$^{235}U = 235.04394\ u$

$^{1}_{0}n = 1.008665\ u$

$m_r = 236.05261\ u$

m_p:

$^{135}Xe = 134.91350$

$^{90}Sr = 89.90715$

$11\ {}^{1}_{0}n = 11 \times 1.008665$

$m_p = 235.916565$

mass defect $= \Delta m = m_p - m_r$

$= 0.136045\ u$

Note $1\ u = 1.66 \times 10^{-27}$ Kg

$\therefore\ \Delta m \times 1u$ of mass in kg $= 2.258 \times 10^{-28}$ Kg.

$E = mc^2$

$= 2.258 \times 10^{-28} \times (3 \times 10^{8})^2$

$= 2.0322 \times 10^{-11}$ J / fission.

b) J/kg

Mass of one U-235 atom is 235.04394 u

$1.66 \times 10^{-27} \times$

$= 3.902 \times 10^{-25}$ kg

Energy released by 1kg of fission =

$$2.0322 \times 10^{-11} \text{ J} \times \frac{1 \text{kg}}{3.902 \times 10^{-25}} = \_\_\_ \text{ J/kg}$$

$\Leftrightarrow 5.208 \times 10^{13}$ J/kg.

Q18.

a) ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$

mass of reactants

$2H = 2.014102$

$3H = 3.016050$

$m_r = 5.030152$

mass of products

$4He = 4.002603$

$1n = 1.008665$

$m_p = 5.011268$

mass defect $= m_p - m_r$

$= -0.018884 \, u$

$1 \, u = 1.66 \times 10^{-27}$ Kg.

$\therefore m = -3.134744 \times 10^{-29}$ Kg

$E = mc^2$

$\times (3 \times 10^8)^2$

$=$

$= -2.82 \times 10^{-12}$ J / fusion reaction

Q18

b) $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$

m_r = mass of $2 \times {}^{2}H_1 = 2 \times 2.014102 = 4.028204$

$m_p = 3.016030 + 1.008665 = 4.024695$

$\Delta m = m_p - m_r = -3.509 \times 10^{-3}\ u$

note $1\ u = 1.66 \times 10^{-27}$ Kg

$\Delta m = -5.82494 \times 10^{-30}$

$E = mc^2$

$= \quad \times (3 \times 10^8)^2$

$= -5.242 \times 10^{-13}$ J / fusion reaction

Q18

i) $^{2}_{1}H + ^{3}_{2}He \rightarrow ^{4}_{2}He + ^{1}_{1}p$

$m_r = 2.014102 + 3.016030 = 5.030132$ u.

$m_p = 4.002603 + 1.007276 = 5.009879.$

$\Delta m = m_p - m_r = -0.02055$ u.

note $1\ u = 1.66 \times 10^{-27}$ Kg.

$m = -3.361998 \times 10^{-29}$ Kg.

$E = mc^2$

$= \times (3 \times 10^8)^2$

$= -3.02 \times 10^{-12}$ J/fusion

(c) n the highest energy level.